METHODS

Baseflow Sampling

This report focuses on the northern Lake Washington tributaries including the Sammamish River. Monitoring sites in the Sammamish River basin are located at both the head and mouth of the Sammamish River, six sites on Bear-Evans Creek, three sites on Issaquah Creek, and at the mouths of Swamp, North, and Little Bear Creeks. The four streams monitored which drain into the north end of Lake Washington are McAleer, Lyon, Thornton, and Juanita Creeks. Also covered in this report are four sites in the Soos Creek basin. The Soos Creek basin sites were evaluated as an element of the County's Stormwater NPDES effectiveness evaluation completed for the 4th annual report to Ecology.

Monthly baseflow samples were collected beginning in 1979 at sixteen sites in the Sammamish River/North Lake Washington drainage basin and four sites in the Soos Creek drainage basin (Figures 1a and 1b, and Table 1). The period of record for most sites and parameters (Table 2) was twenty years, with other parameters added later. Enterococcus bacteria have been monitored beginning in 1988 and total nitrogen began in 1994. Baseflow samples were taken to the King County Laboratory for analysis of thirteen parameters. (Laboratory analytical methods are discussed in Appendix I).

Table 1. Sampling and Gauge Locations, Drainage Area (square miles), and Number of Sample Events

Stream	Drainage area (mi^2)	Locator	Gauge	Baseline	Storm	Sediment
Lyon	3.7	0430	34A	238	30	12
McAleer	7.8	A432	35D	242	47	12
Thornton	12.1	0434	58B	237	30	12
Sammamish River						
at Kenmore		0450		230		
at Marymoor		0486		230		
Swamp	23	0470	56A	236	27	12
North	27	0474		234	27	12
Little Bear	15.3	0478	30A	240	28	12
Bear-Evans	48.2					
at Mouth		0484	02J	235		
at N.E. 95th St.		C484		238		
at 19500 Seidel Rd.		J484		234		
Cottage Creek		N484		234		
Evans at Bear		B484		278		
Upstream Evans		S484		218		
Juanita Creek	6.7					
at Mouth		0446	27A	236	47	12
at 124th St		C446		237		
Soos	66.7					
above Hatchery		A320	54A	233	47	12
Covington		C320		239		
Jenkins		D320		232		
Little Soos		G320		228		

Table 2. Number of stream measurements for selected parameters between 1976 and 1999.

PARAMETER	BASEFLOW	STORM	SEDIMENT
Flow	2,605	136	
Conventionals			
• Dissolved oxygen	4,574	313	
• Temperature	4,940	328	
• Turbidity	4,800	330	
• Total Suspended Solids	4,817	330	
• pH	4,429	305	
• Conductivity	4,807	327	
Nutrients			
• Ortho Phosphorus	4,654	330	
• Total Phosphorus	4,474	330	
• Ammonia Nitrogen	3,966	287	
• Nitrate + Nitrite	4,738	330	
• Total Nitrogen	1,626	210	
Bacteria			
• Enterococcus	2,649	325	
• Fecal coliform bacteria	4,815	330	
Trace Metals			
• Cadmium	0	2,520	672
• Copper	0	2,520	672
• Lead	0	2,520	672
• Mercury	0	2,520	672
• Nickel	0	2,520	672
• Silver	0	2,520	672
• Zinc	0	2,520	672

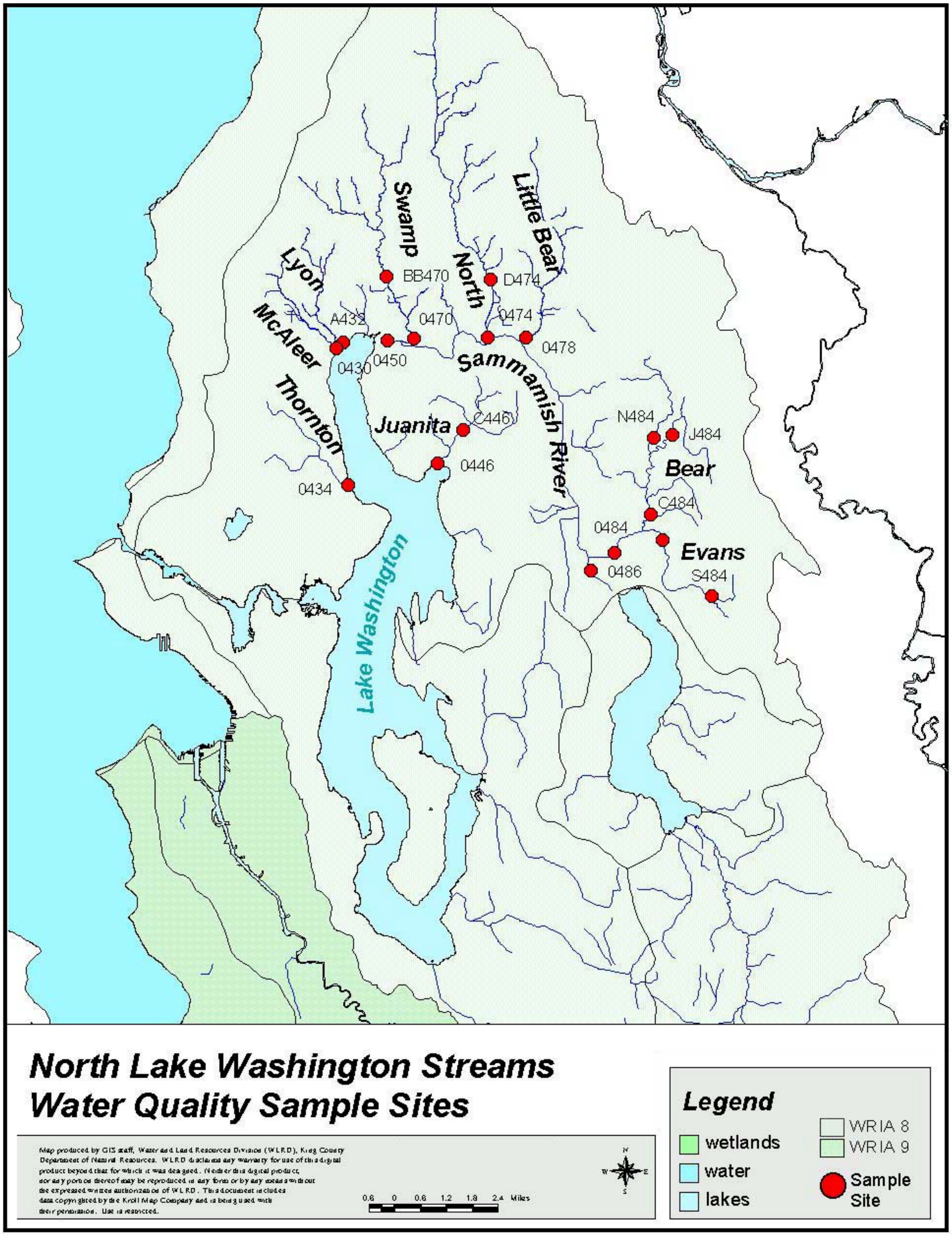

Figure 1a. North Lake Washington streams Water Quality Sample Sites

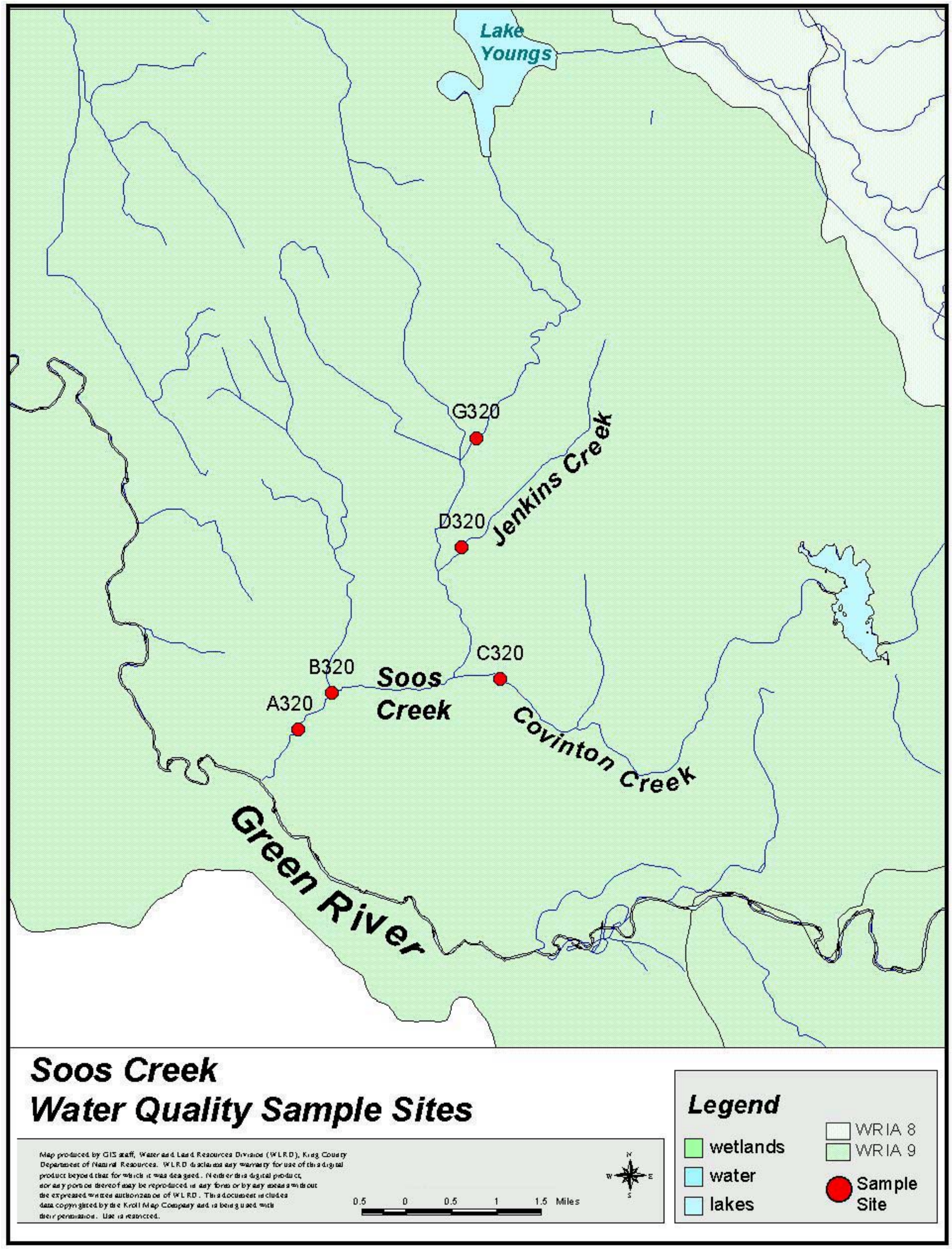

Figure 1b. Soos Creek Water Quality Sample Sites

Storm Water Sampling

Storm monitoring efforts focus on sampling storms spread throughout the wet season (October – May). Beginning in 1987, storm samples were collected three to six times annually at sites located at the mouth of streams (Table 1). The mouth of the Sammamish River was not sampled during storm events. Storm samples were analyzed for the same parameters as baseflow samples plus trace metals. In addition, sediment samples were collected annually at these same eight locations. Three sediment cores were collected at each site, composited, and a subsample was analyzed for trace metals.

Once each year the invertebrate benthos are sampled at each of the monitoring sites. Results of the invertebrate analysis will be presented in another document that is expected to be published in 2002.

State and Federal Water Quality Criteria

The following State and Federal water quality criteria were used to evaluate the stream data.

Washington State Department of Ecology - Water Quality Criteria

The Washington State Department of Ecology classifies all sites in this program as “A-A – Extraordinary” according to (Washington Administrative Code [WAC] 173-201A). The baseline monthly data were compared to the class AA standards for fecal coliform bacteria, dissolved oxygen, temperature, and pH. Those standards are listed as follows:

- ***Fecal Coliform*** - Geometric mean value shall not exceed 50 organisms per 100 ml with not more than 10% of the samples exceeding 100 organisms per 100 ml
- ***Dissolved oxygen*** - shall exceed 9.5 mg/L
- ***Temperature*** - Shall not exceed 16 °C.
- ***pH*** - shall be between 6.5 and 8.5
- ***Turbidity*** - Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase when the background turbidity is more than 50 NTU.

Criteria for Trace Metals in Storm Water

The concentration of metals from unfiltered storm water samples was evaluated using the Washington State Water Quality Standards for Surface Waters (Washington Administrative Code [WAC] 173-201A). Toxicity of many metals is dependent upon the hardness of the water – the harder the water, the less toxic the metal (see page 58 for a more in-depth discussion). Hardness of each water sample was calculated from its calcium and magnesium concentrations and, using the calculated hardness, calculations for acute toxicity of the sampled metals were then done. Equations for calculating hardness and acute toxicity criteria are as follows (Washington Administrative Code [WAC] 173-201A):

- **Hardness**: using the values for calcium (mg/L) and magnesium (mg/L): Hardness = (2.497*Ca)+(4.1189*Mg).
- **Acute toxicity criteria**:

  Cadmium $\leq$ (1.136672-[(ln Hardness)(.041838)]($e^{(1.128(\ln(hardness))-3.28)}$)

  Chromium^{+++} $\leq$ (.316)($e^{(.819(\ln(hardness))+3.688)}$)

  Copper $\leq$ (.960)($e^{(.9422(\ln(hardness))-1.464)}$)

  Lead $\leq$ (1.46203-(ln hardness)(.145712)])($e^{(1.237(\ln(hardness))-1.46)}$)

  Nickel $\leq$ (.998)($e^{(.846(\ln(hardness))+3.3612)}$)

  Silver $\leq$ (0.85)*($e^{(1.72*(\ln(hardness))-6.52)}$)

  Zinc $\leq$ (.978)($e^{(.8473(\ln(hardness))+.8604)}$)

  Mercury will not exceed 2.1 µg/L. (The criterion for this metal is not dependent on hardness.)

Apparent Effects Thresholds for Trace Metals in Sediments

Sediment samples were analyzed for copper (Cu), total chromium (Cr_{total}), cadmium (Cd), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn). Currently there are no State criteria for metals in freshwater sediment, therefore the resultant data were compared to sediment thresholds as presented in *Creation and Analysis of Freshwater Sediment Quality Values in Washington State* (WSDOE, 1997).

Statistical Methods

Many basic ecological problems and their solutions require study of a system over a long period of time. Due to the natural variability that occurs in the environment from season to season and year to year, often the discovery of a significant change (whether it be an improvement or degradation) can occur only when looking at a long period of record. For this report, several methods were used to evaluate the existence of long-term trends in each data set and determine significant differences between sampling locations (Haber and Runyon, 1973).

Time-Series Plots. A preliminary screening tool for trend analysis is the time-series plot (Figure 2). If a significant long-term trend exists, it may be apparent upon visual examination of a plot of the raw data. Many parameters exhibit strong seasonality and therefore a “typical” range of monthly values was determined using the stream sample data. The "typical" range was defined to encompass approximately 70% of the values for each month sample data existed (e.g., fifteen percent of the values should exceed the high range value and fifteen percent should be lower than low range value). The shaded area (illustrated in Figure 2) represents the "typical" range across the middle of each plot. Comparing the data points for each site to that shaded area makes the trends more apparent should they exist.

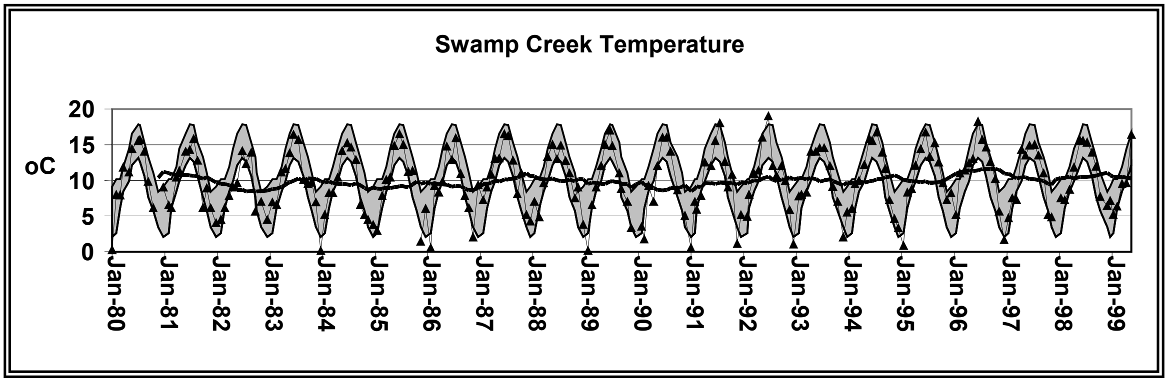

Figure 2. Example of a Time Series Plot. (Shaded area represents the "typical range." Solid line represents the Moving Mean).

<u>*Moving Mean Plot*</u> - Seasonal variability for dissolved oxygen and temperature data were too great to use the time series plots to identify long-term trends so a twelve-month moving mean was calculated for each site. The moving mean smoothes out seasonality in many cases and makes long-term trends easier to see. If the moving mean plot suggest that a trend might exist, the raw data were then analyzed further for trend analysis.

To correctly calculate a moving mean, data must be collected at regular intervals. In this case, monthly baseline data for temperature and dissolved oxygen was used. The moving mean is determined by calculating averages for 12-month intervals beginning with the first 12 data. For example, January 1980 through December 1980. The next point would be the average of February 1980 through January 1981; the third point would be the average of March 1980 through February 1981, and so on until the last data point was incorporated into a mean. When the means are plotted (Figure 2), the line may suggest a trend that would not be obvious given the seasonal variability of the raw data.

Seasonal Kendall's Trend Test - If the time series plot or the moving mean plot suggested a trend, the Seasonal Kendall's Trend Test was used for further evaluation. This non-parametric test is especially useful for data that display seasonality.

Mann Whitney Test - This test was used to determine whether water quality data collected at two sampling locations were statistically different from each other.

Spearman's rho - Spearman's rho is a statistical tool that compares ordered ranks rather than the actual values of the parameters being compared and is used primarily as a screening tool. If the test does not detect a significant correlation between two sets of ranked data (i.e., year to year, site to site, season to season), a trend is not likely to be detected by more sensitive analyses.

Discussion Format

Discussion of the parameters falls into four main categories:

- **Conventionals** (Dissolved oxygen, Temperature, Turbidity, Total Suspended Solids, pH, Conductivity),
- **Nutrients** (Ammonia-nitrogen [NH_4], Nitrite+nitrate-nitrogen [NO_2-NO_3], and Total-nitrogen [TN], and Phosphorus as Ortho-Phosphorus [Ortho-P] and Total-Phosphorus [TP]),
- **Bacteria** (Enterococcus and Fecal Coliform bacteria)
- **Trace metals** (Hardness, Cadmium, Copper, Lead, Mercury, Nickel, Silver, and Zinc in storm water and sediment).

Within each of these four categories data were analyzed in terms of sampling regiment (baseline versus storm event), seasonal trends (wet versus dry season), and long-term trend analysis as follows:

> Baseline Data. Data are summarized (min, max, mean) for each of the sixteen sites and for all sites combined. The Mann Whitney test was used to determine if differences between sites were significant. Differences between sites are discussed. Whether or not applicable State and Federal water quality criteria were met is also discussed. For each site, a table listing the minimum, maximum, average and number of samples not meeting criteria can be found in Appendix II.
>
> Storm Data. Stormwater values are compared to the appropriate criteria and discussed. Stormwater data summary tables appear in Appendix III.

Wet/Dry Seasons. Wet season (October through March), dry season (April through September) and storm average levels are compared for each site. (See the bar charts in Appendix III.)

Long-Term Trends. Time-series plots for each parameter were evaluated to determine water quality trends over the 20 year period of record. (See Appendix IV.) The Seasonal Kendall's Trend Test was used to confirm whether the trends apparent in the time series plots were statistically significant at the 90% confidence level. Some parameters appeared to be linked to others. Spearman's Rho rank-order correlation coefficients were calculated to estimate the strength of those links.